# RS/4/C/003-2017

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RATING STANDARD
for the
CERTIFICATION
of
**Residential Air Filters**

# RS/4/C/003-2017

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Published by Eurovent Certita Certification
48-50 rue de la Victoire
75009 Paris, FRANCE

Tel: + 33 1 75 44 71 71
E-mail: apply@eurovent-certification.com

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# I. PURPOSE

The purpose of this Rating Standard is to establish definitions and specifications for testing and rating of Residential Air Filters (RFIL), for the related Eurovent Certified Performance (ECP) certification programme, in accordance with Operational Manual OM-21.

# II. SCOPE

Please refer to related paragraph in the Operational Manual OM-21.

# III. DEFINITIONS

For definitions regarding the certification scheme refer to Certification Manual.
Definitions that appear in relevant testing standards (see §IV.1) apply.

### III.1. Adsorption capacity

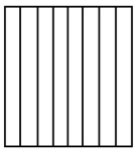
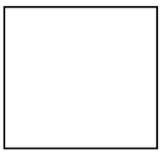
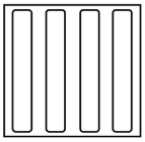
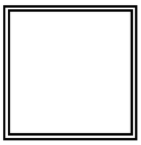
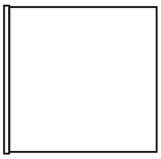
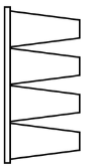
Mass of contaminant $m_c$ [mg] removed from the challenge gas stream by the filter. The adsorption capacity is determined based on the contaminant removal efficiency (see §III.5) measured values over the total test time (see §III.21). The calculation method is described in Annex C of standard ISO 11155-2:2009.

### III.2. Basic design

The basic design of a filter designates the arrangement of the filtering area which can be the following:

- Bag : Media arranged in several bags
- Panel : Media pleat which depth is < 150 mm
- V-type : Media pleats arranged in several V-shaped rigid sections
- Pleated : Deep media pleat (depth ≥ 150 mm)

***Table 1 : Illustration of the filter basic designs***

| | Bag | Panel | V-type | Pleated |
|---|---|---|---|---|
| Frontal view |  |  |  |  |
| Side view |  |  |  |  |

### III.3. Clean Air Efficiency

The Clean Air Efficiency for Residential Air Filters ($CAE_{RFIL}$) can be defined as the amount of clean air delivered by the filter per unit of consumed energy.

This value, expressed in [$m^3$/h/kWh/a], is calculated according to the method described in Appendix A.

### III.4. Combination filter

A combination filter designates a particulate filter which material or extra layer(s) present(s) additional filtration properties, intrinsically or after being treated or coated, such as gaseous filtration (see III.10).

### III.5. Contaminant removal efficiency

Ratio of the amount of contaminant removed or reduced by the filter relative to the amount exposed to it, calculated as described in standard ISO 11155-2:2009 and expressed in [%].

### III.6. Contaminant removal efficiency measurement time

Measurement time $t_m$ (min) after time zero (see §III.22) for the contaminant removal efficiency (see §III.5) determination.

### III.7. Effluent concentration

Homogeneous challenge gas concentration measured after (downstream of) the filter, noted $C_2$ and expressed in [mg/m$^3$].

### III.8. Filter depth

Overall depth of the filter including the frame (complete filter). The filter depth defined here (and declared in the form RFIL-1) is not the one used to calculate the filtering area.

### III.9. Filter family

A filter family is characterised by the following:

- the same filter material
- the same basic design (see §III.2)
- the same face velocity (rated airflow / minimum net filter face area)
- the same
    - depth (see III.8) of the overall filter element, with a tolerance of +/- 10% but not lower than 5 mm, for panel filters and pleated filters
    - ratio of filter medium area to front face area, with a tolerance of +/- 10%, for bag filters, V-type filters, pleated filters and panel filters
- the same initial pressure drop, with a tolerance of +/- 10% but not lower than 5 Pa
- the same ISO ePM class reporting value

Among these data, the following must be available via internet or published sales brochures: basic construction, filter media, ISO group for filter classification.

### III.10. Gaseous filtration

The gaseous filtration consists in the separation of one or more constituents of a gaseous mixture (here the contaminated air). Gaseous filtration is often achieved by adsorption (see also §III.1).

### III.11. Influent concentration

Homogeneous challenge gas concentration measured before (upstream of) the filter, noted $C_1$ and expressed in [mg/m$^3$].

### III.12. Initial efficiency

Efficiency of the clean filter operating at a given flow rate.

The symbol ePMx describes the initial efficiency of a filter element to reduce the mass concentration of particles with an optical diameter between 0,3 µm and x µm.

### III.13. Initial pressure drop

Pressure drop of the clean filter operating at a given flow rate.

### III.14. ISO ePMx class reporting value

Class reporting value, corresponding to the initial efficiency ePMx value (see §III.12) rounded downwards to the nearest multiple of 5 percentage points, in conjunction with the group name.

Example: ISO ePM1 85%.

### III.15. ISO groups for filters classification

The ISO groups for filters classification are defined as per document Eurovent 4/22:2015, excluding ISO Coarse which is not part of the RFIL certification programme scope (see §II) as follows:

***Table 2 : ISO groups for filters classification (source: Eurovent 4/22:2015)***

| ***Group name*** | ***Requirement*** | | | ***Class reporting value*** |
|---|---|---|---|---|
| | ***$ePM_{1,min}$*** | ***$ePM_{2,5,min}$*** | ***$ePM_{10}$*** | |
| ISO $ePM_{10}$ | | | ≥50% | $ePM_{10}$ |
| ISO $ePM_{2,5}$ | | ≥50% | | $ePM_{2,5}$ |
| ISO $ePM_{1}$ | ≥50% | | | $ePM_{1}$ |

### III.16. Minimum efficiency

The symbol $ePM_{x,min}$ describes the minimum efficiency value of the conditioned (discharged) filter element, operating at a given air flow rate, to reduce the mass concentration of particles with an optical diameter between 0,3 µm and x µm.

### III.17. Rated maximum airflow

Maximum operational air flow for the filter as recommended by the manufacturer. It is expressed in [$m^3/h$].

### III.18. Reference velocity

Ratio between the rated maximum airflow and the net filter face area corresponding to an A4 format (i.e 210 mm x 297 mm). It is expressed in [m/s].

### III.19. Residential Ventilation Unit

The definition that appears in EU regulation 1253/2014 specifies that a ventilation unit is considered residential when:

- the maximum flow rate does not exceed 250 $m^3/h$;
- the maximum flow rate is between 250 and 1 000 $m^3/h$ and the manufacturer declares its intended use as being exclusively for a residential ventilation application;

### III.20. Specific Energy Consumption of a residential air filter

The Specific Energy Consumption of a residential air filter ($SEC_{RFIL}$) is the expression of the energy consumed by the fan to overcome the pressure drop caused by the filter in a given Residential Ventilation Unit (see §III.19).

This value, expressed in [$kWh/m^2/a$], is calculated according to the method described in Appendix A. The $SEC_{RFIL}$ is used to determine the Clean Air Efficiency (see §III.3) of the filter.

### III.21. Total test time

The total test time is the duration of exposure of the filter to the challenge gas, beginning at time zero ($t_0$ see also §III.22).

### III.22. Time zero

The time zero ($t_0$) is the calculated zero point based on the shape of the ramp-up curve of challenge gas breakthrough versus time. The calculation method is described in Annex B of standard ISO 11155-2:2009.

## IV. TESTING REQUIREMENTS

### IV.1. Test standards

Test shall be conducted in accordance with (see also §IV.2 and §IV.3):

- Eurovent 4/22:2015: Industry Recommendation for Residential Air Filter Performance measurements;
- ISO 16890:2016: Air filters for general ventilation
    - Part 1: Technical specifications, requirements and classification system based upon particulate matter efficiency (ePM)
    - Part 4: Conditioning method to determine the minimum fractional test efficiency
- ISO 11155-2:2009: Road vehicles - Air filters for passenger compartments - Part 2: Test for gaseous filtration

The test rig shall comply with the requirements specified in Annex C of standard:

- ISO/TS 11155-1:2001: Road vehicles - Air filters for passenger compartments - Part 1: Test for particulate filtration

The measuring tolerance shall be in accordance with Annex E of aforementioned standard ISO/TS 11155-1:2001.

### IV.2. Particular specifications for testing

The following specifications are applicable for qualification tests and repetition tests.

**a. <u>Air density</u>**

The density of the test air shall be maintained constant and recorded so that the ratings can be transposed to standard air density (see §V.1).

**b. <u>Airflow rate</u>**

The filter shall be tested at the rated maximum airflow (see §III.17).

**c. <u>Challenge gas</u>**

When testing combination filters the challenge gas shall be Toluene.

### IV.3. Test procedure

#### a. Dimensional check before testing

Before testing the filter, the independent laboratory shall verify that the delivered filter corresponds to the selection, notably by checking its dimensions against the values displayed in the technical datasheet:

- The face area dimensions (height and width) shall not differ by more than the tolerance (+0 ; -2 mm).
- The depth of the overall filter element shall not differ by more than the tolerance (+0 ; -2 mm), for panel filters and pleated filters.
- The depth of the bag or V-type filter shall not differ by more than the tolerance (+0 ; -2 mm).

#### b. Particulate filtration performance testing

The test related to particulate filtration shall be done in accordance with the method described in Eurovent 4/22:2015.

#### c. Gaseous filtration performance testing

When testing combination filters, the part related to gaseous filtration performance testing shall be done in accordance with standard ISO 11155-2:2009.

## V. RATING REQUIREMENTS

### V.1. Air density

Standard air density is set at 1.20 kg/m$^3$. It is mandatory to display the certified performances items under the standard conditions in the published ratings. It is allowed to display any other values if accompanied by the underlying air density.

### V.2. Face velocity

The ratings shall be made for the face velocity corresponding to the rated maximum air flow (see §III.17) and a net filter face area corresponding to an A4 format (i.e face dimensions 210 mm x 297 mm), referred to as reference velocity (see §III.18) in the certification programme.

## VI. CERTIFIED PERFORMANCE ITEMS

For particulate filters the certified characteristics are the following:

- Initial pressure drop at 100% of the rated maximum airflow [Pa]
- Initial efficiencies ($ePM_1$, $ePM_{2,5}$ , $ePM_{10}$) [%]
- Minimum efficiencies ($ePM_{1,min}$, $ePM_{2,5,min}$) [%]
- Filter ISO $ePM_x$ class reporting value (ISO $ePM_x$ YY) [%]

For combination filters (see definition in §III.4) the certified characteristics are:

- Initial pressure drop at 100% of the rated maximum airflow [Pa]
- Initial efficiencies ($ePM_1$, $ePM_{2,5}$ , $ePM_{10}$) [%]
- Minimum efficiencies ($ePM_{1,min}$, $ePM_{2,5,min}$) [%]
- Filter ISO $ePM_x$ class reporting value (ISO $ePM_x$ YY) [%]
- Adsorption capacity for Toluene [mg]

## VII. TOLERANCES

When tested in the laboratory the obtained performance data shall not differ from the declared values by more than the following tolerance values:

- Initial pressure drop values +10%+Mt or +10 Pa +Mt
- Initial efficiency values -5 percentage points (absolute deviation)
- Minimum efficiency values -5 percentage points (absolute deviation)
- Filter ISO ePMx class reporting value -5 percentage points (absolute deviation)
- Adsorption capacity -10%

Considering Mt as the measuring tolerance as allowed in standard EN 779:2012 that equals 5 Pa.

The relative deviation (in %) between the measured value $X_{meas}$ and the declared value $X_{decl}$ is calculated as follows:

$\Delta_{rel} = (X_{meas} - X_{decl}) / X_{decl}$

The absolute deviation between the measured value $X_{meas}$ and the declared value $X_{decl}$ is calculated as follows:

$\Delta_{abs} = X_{meas} - X_{decl}$

If any of individual points of measurement shows a deviation larger than the acceptable tolerance, the failure shall be declared and the failure procedure applied.

# APPENDIX A. CALCULATION METHOD FOR THE CLEAN AIR EFFICIENCY

## A.I. Specific Energy Consumption for Residential Air Filters

### A.I.1) Default values considered in the calculation

To enhance comparability of the ratings, the filter is assessed considering a given Residential Air Handling Unit (RAHU) configuration. This configuration, corresponding to ducted units, central demand control and variable speed drive, is defined using the associated default values specified in regulation 1253/2014 and reminded in the following table:

***Table 3 : SEC calculation parameters values considered (source regulation 1253/2014)***

| *Designation* | *Reference* | *Value considered* | *Unit* |
|---|---|---|---|
| annual operation time | $t_a$ | 8760 | h/a |
| primary energy factor | pef | 2.5 | - |
| ventilation rate demand per $m^2$ of heated floor area | $q_{net}$ | 1.3 | $m^3/h.m^2$ |
| aggregated typology factor | MISC | 1.1 | - |
| ventilation control factor | CTRL | 0.85 | - |
| non-linearity exponent for motor and drive | x | 2 | - |
| fan efficiency | $\eta_{fan}$ | 0.5 | - |

### A.I.2) Yearly Energy Consumption $W_{RFIL}$

As for “large” air filters (FIL programme), the energy consumption of Residential Air Filters (portion of the ventilation unit energy consumption related to the filter’s pressure drop) can be determined as a function of:

- the nominal volume flow rate $q_v$ [$m^3/s$]
- the fan efficiency $\eta_{fan}$ (see Table 3)
- the annual operation time $t_a$ [h/a] (see Table 3)
- the initial pressure drop $\Delta p_{100\%}$ [Pa]

The yearly energy consumption $W_{RFIL}$ [kWh/a] of a Residential Air Filter is therefore:

$$W_{RFIL} = \frac{q_v \cdot \Delta p_{100\%} \cdot t_a}{\eta_{fan} \cdot 1000}$$

### A.I.3) Specific Power Input $SPI_{RFIL}$

The specific power input $SPI_{RFIL}$ [$kW/(m^3.h^{-1})$] of a Residential Air Filter can be deduced from the yearly energy consumption $W_{RFIL}$ as follows:

$$SPI_{RFIL} = \frac{W_{RFIL}}{3600 \cdot q_v \cdot t_a} = \frac{\Delta p_{100\%}}{\eta_{fan} \cdot 3600 \cdot 1000}$$

### A.I.4) Specific Energy Consumption $SEC_{RFIL}$

The specific energy consumption related to Residential Air Filters ($SEC_{RFIL}$ defined in §III.20 and expressed in [kWh/(m².a)]) is:

$$SEC_{RFIL} = t_a \cdot pef \cdot q_{net} \cdot MISC \cdot CTRL^x \cdot SPI_{RFIL}$$

Given the $SPI_{RFIL}$ expression displayed in §A.I.3) the formula can also be expressed as follows:

$$SEC_{RFIL} = t_a \cdot p_{ef} \cdot q_{net} \cdot MISC \cdot CTRL^x \cdot \frac{\Delta p_{100\%}}{\eta_{fan} \cdot 3600 \cdot 1000}$$

Considering the default values given in Table 3 the formula becomes:

$$SEC_{RFIL} = 8760 \cdot 2.5 \cdot 1.3 \cdot 1.1 \cdot 0.85^2 \cdot \frac{\Delta p_{100\%}}{0.5 \cdot 3600 \cdot 1000}$$

$$SEC_{RFIL} = 1.26 \cdot 10^{-2} \cdot \Delta p_{100\%}$$

## A.II. Clean Air Efficiency for Residential Air Filters

The Clean Air Efficiency for Residential Air Filters ($CAE_{RFIL}$), defined in §III.3 and expressed in [m³/h/kWh/a], can be determined by the following formula:

$$CAE_{RFIL} = \frac{ePM_1 \cdot q_v}{SEC_{RFIL} \cdot \frac{q_v}{q_{net}}} = q_{net} \cdot \frac{ePM_1}{SEC_{RFIL}}$$

Given the default values displayed in Table 3, the formula becomes:

$$CAE_{RFIL} = 1.3 \cdot \frac{ePM_1}{SEC_{RFIL}}$$

and

$$CAE_{RFIL} = \frac{1.3 \cdot ePM_1}{1.26 \cdot 10^{-2} \cdot \Delta p_{100\%}} = 103.4 \cdot \frac{ePM_1}{\Delta p_{100\%}}$$

The Clean Air Efficiency can therefore be deduced from certified performance items (see §VI):

- initial efficiency $ePM_1$ [-]
- initial pressure drop $\Delta p_{100\%}$ [Pa]